



## **Scanflow: High-resolution full-scale wind field measurements of the ECN's 2.5 MW aerodynamic research wind turbine using DTU's 3D WindScanner and SpinnerLidar for IRPWind's and EERA's benchmark**

**Hasager, Charlotte Bay; Mikkelsen, Torben Krogh; Angelou, Nikolas; Pena Diaz, Alfredo; Giebel, Gregor; Wagenaar, Jan Willem; Schepers, Gerard; Werkhoven, Erwin**

*Publication date:*  
2016

*Document Version*  
Peer reviewed version

[Link back to DTU Orbit](#)

### *Citation (APA):*

Hasager, C. B. (Author), Mikkelsen, T. K. (Author), Angelou, N. (Author), Pena Diaz, A. (Author), Giebel, G. (Author), Wagenaar, J. W. (Author), Schepers, G. (Author), & Werkhoven, E. (Author). (2016). Scanflow: High-resolution full-scale wind field measurements of the ECN's 2.5 MW aerodynamic research wind turbine using DTU's 3D WindScanner and SpinnerLidar for IRPWind's and EERA's benchmark. Sound/Visual production (digital)

---

### **General rights**

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

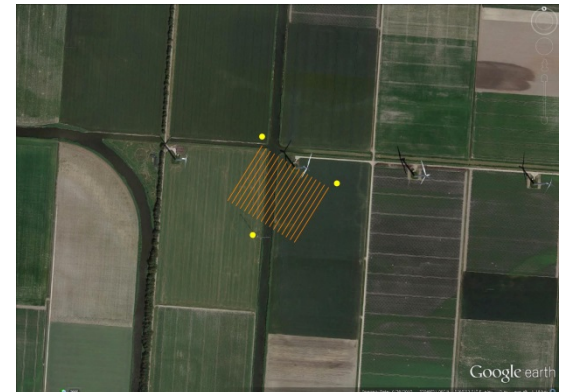
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.



# Research topics and originality

We aim to establish a unique turbine power performance and induction zone benchmark experiment by operating a DTU developed high-resolution nacelle integrated 2D SpinnerLidar installed in a research wind turbine at ECN.

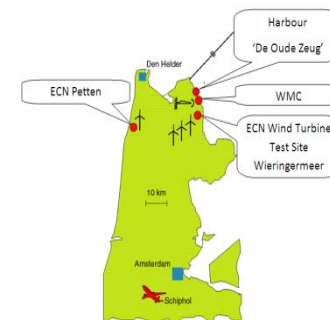
Concurrently, three ground-based short-range WindScanner lidars from DTU will be deployed to perform 3D wind velocity field observations Cf. [WindScanner.dk](http://WindScanner.dk) and [WindScanner.eu](http://WindScanner.eu)



# ECN Test Site (EWTW)

## ECN Wind turbine Test station Wieringermeer

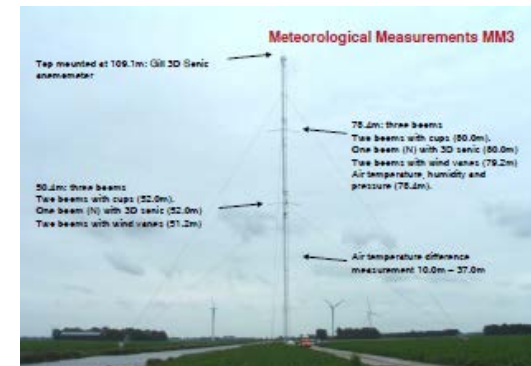
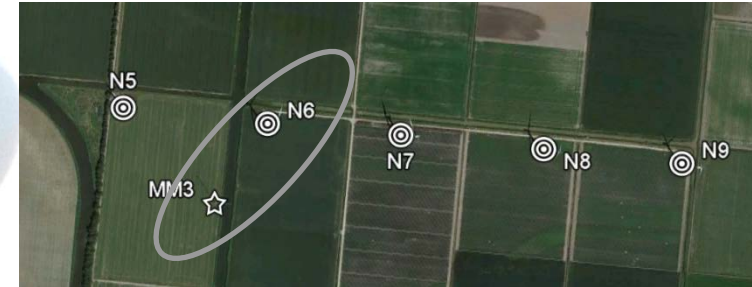
- Prototype turbines and masts
  - 6 prototypes: 2MW-5MW, D=100m-120m
  - 4 IEC compliant meteorological masts
- Research turbines and mast
  - 5 ECN research turbines East-West
  - IEC compliant meteorological mast
- Measurement pavilion
  - Data gathering and transfer to ECN



# ECN test site set-up

- Meteorological mast 3
  - Cups, vanes and sonics @ 52m, 80m, 108m
  - Temperature, pressure, etc
- ECN research turbine
  - Nordex, 2.5MW
  - $H=D=80m$
- Over 10 years of experiences. High quality measurements

- Installation on N6
  - 2<sup>nd</sup> in row from West
  - On top of cooler

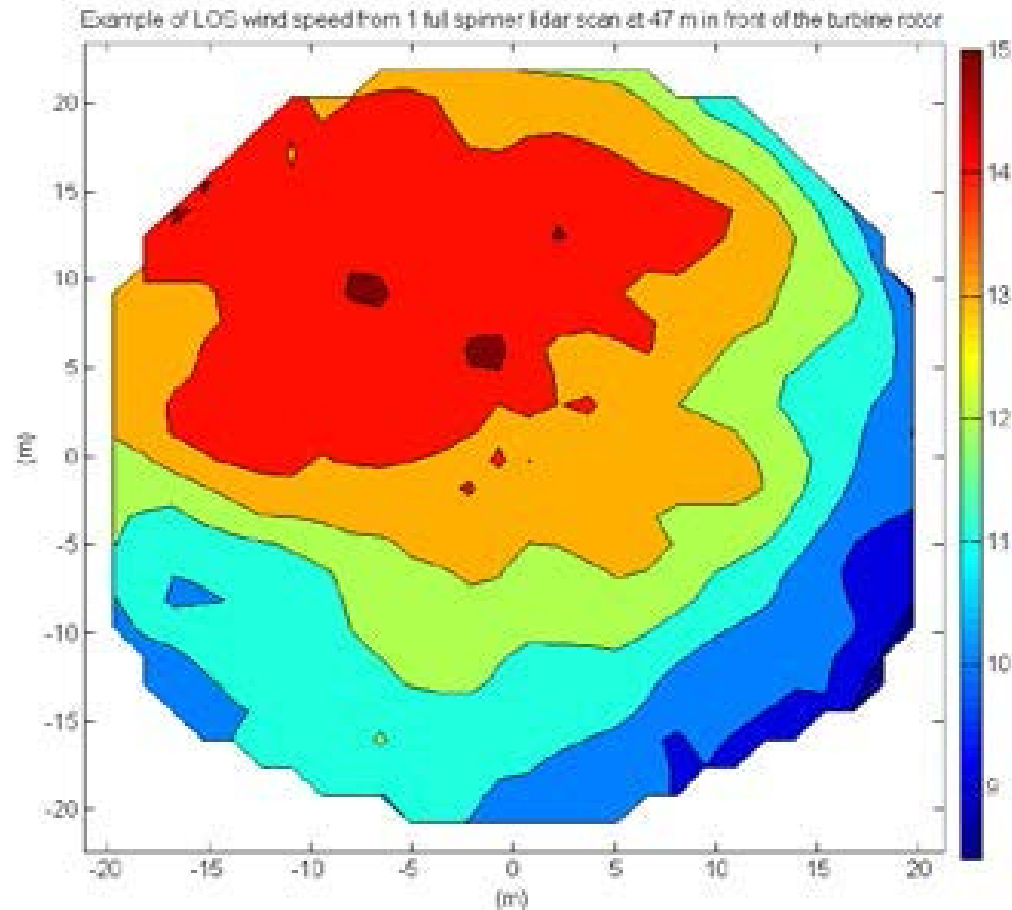


# DTU 2D SpinnerLidar on Risø Campus NordTank during the UniTTE<sup>1</sup> field test 2015



<sup>1</sup>Wagner R, Vignaroli A, Angelou N, Sathe A, Meyer Forsting A R, Sjöholm M, Mikkelsen T 2015  
MEASUREMENT OF TURBINE INFLOW WITH A 3D WINDSCANNER SYSTEM AND A SPINNERLIDAR  
DEWEK 2015 pp 7–10

# A single 2D SpinnerLidar measurement during UniTTE 2015 (4 s sampling period)





# Experimental evaluation ECN 2016: Synchronized 3D scanning short-range WindScanners





# Outcome

- The **ScanFlow** project will provide a **state-of-the-art inflow dataset** useful for evaluation of aerodynamic models ranging from engineering-like up to computational fluid dynamics models, models of the inflow and induction zone.
- A proof-of concept testing of the new advanced software for wind reconstruction using the LINCOM model based on the anti-Cyclop buster methodology program will be applied. The idea of the latter is to extract all three wind components of the **inflow in front of the rotor from a single SpinnerLidar**.
- The result will be compared with the **“true” ground based measurements of the three wind speed components (u,v,w) from the three short-range WindScanner** lidars that will measure from the ground.
- The benchmark will be available through an **open access** e-science platform also beyond project time.

# Main components of ScanFlow

- The **WindScanner SpinnerLidar** from DTU will observe during 6 weeks the inflow approaching the research wind turbine.
- The raw data will be transformed into 3D inflow wind velocity fields upwind the rotor plane by methods developed at DTU and compared against **3D short-range WindScanner** observations from DTU during few weeks; thereby establish a limited dataset proof-of concept demo.
- The turbulence will be assessed from an expression combining the **rotor equivalent wind speed and the power fluctuations of the wind turbine** and will be compared to turbulence observed from the WindScanner and turbulence observed from mast observations.

# Work Packages

- **WP1** (DTU) Preparation of short range WindScanners at DTU
- **WP2** (ECN) Preparation of measurement campaigns
- **WP3** (ECN) 6 week measurement campaign of the SpinnerLidar (nacelle), including installation, dismantling and shipment
- **WP4** (DTU) 2 week measurement campaign of the short range WindScanners (ground based), including installation, dismantling and shipment
- **WP5** (DTU) Post-processing of collected data. Proof of concept three wind components SpinnerLidar
- **WP6** (ECN) Public database with wind turbine, meteorological and WindScanner data. Workshop with database announcement  
(18-20 January 2017 EERA DeepWind Conference, Trondheim)

# Gantt diagram, Deliverables and Milestones

Extension  
Feb. 2017

	June	July	Aug	Sep	Oct	Nov	Dec	Lead
<b>WP1: Prepare WindScanners</b>	X	X	D1					DTU
<b>WP2: Experiment detail plan</b>			D2					ECN
<b>WP3: Nacelle campaign</b>				X	M2			ECN
<b>WP4: Ground campaign</b>				M1				DTU
<b>WP5: Post-processing data</b>					X	X	D3	DTU
<b>WP6: Database/publication</b>				X	X	M3	D4, D5	ECN

D3, M3, D4, D5

D1: Nacelle-based and ground-based lidars ready for experiment

D2: Final experimental plan published

D3: Report on the experiment and proof of concept

D4: Final workshop with external colleagues from EERA and industry invited

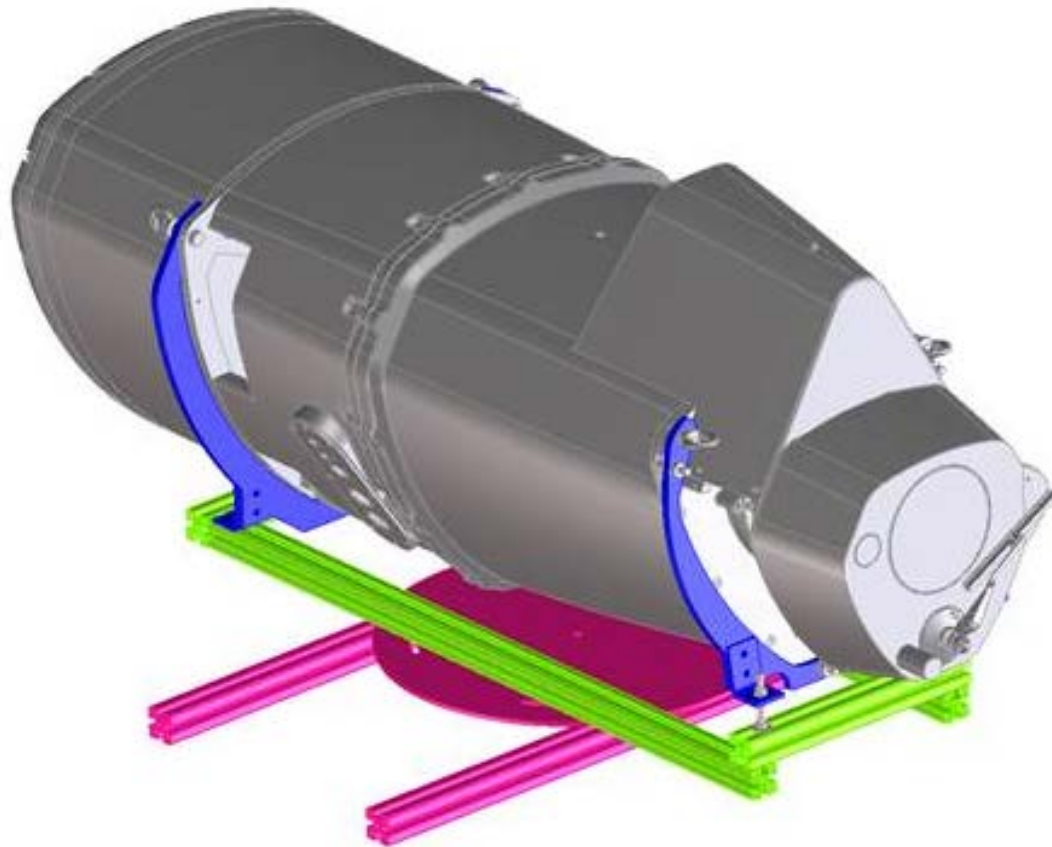
D5: Final project report

M1: Collected 2-weeks of three ground-based WindScanner data

M2: Collected 6-weeks of nacelle-based WindScanner inflow data

M3: Open database launched

# Progress on the SpinnerLIDAR mounting bracket



- The dissemination strategy is to produce 100% open access to the benchmarks on inflow conditions. This will include the 10-minute wind turbine information on power production and the collected WindScanner data.
- The Transfer of Knowledge will be through the dedicated web-sites of
  - ✓ IRPWIND <http://www.irpwind.eu/>
  - ✓ WindScanner.eu <http://www.windscanner.eu/>
  - ✓ WindBench <https://windbench.net/>
- Final presentation at EERA DeepWind Trondheim 2017

# Key Performance Indicators (KPIs)

- Obtain 6 weeks measurements with WindScanner SpinnerLidar at ECN wind turbine test field
- Obtain data from three ground-based short-range WindScanner lidars during a two week campaign
- Deliver the wind turbine 10 minute data power production, pitch angle and rotational speed to public database.
- Deliver WindScanner 10 minute data to public database.